"21"

Hydraulics

3^{rd} Year civil

First Term (2009 - 2010)

Chapter ( )

Revision Part (3)
final 2007

=*Revision*=
(4)

Zagazig University
Faculty of Engineering
Water & Water Structures Eng. Dept.

Hydraulics1
1^{st} Term Final Exam
time allowed 3 hours

Attempt All questions. Make your answers clear and brief. Use neat sketches as possible as you can. Any unnecessary answers should be avoided. The examination consisted of 6 questions written in two pages.

Question No. 1 (20%)

a) Define each of the following: CDL, RVF, GVF, NPSH and TDH.
b) Prove that ($Q^2/g = A^3/T$) at critical flow conditions for open channels having non-rectangular.
c) Derive the dynamic equation of the gradually varied flow.
d) Prove that (~~y=R/2~~) is the condition of best hydraulic rectangular section of an open channel. R=y/2
e) Prove that the discharge over a broad crested weir may be expressed as $Q=1.705C_d b(E-p)^{1.5}$ where C_d is the discharge coefficient, b is the width of the weir crest, E is the total head US the weir and p is the weir height.
f) Prove that for modeling of flow over spillway, the discharge ratio is given by $Qr=L_r^{2.5}$.
g) What is the importance of dimensional analysis technique?
h) What is the importance of hydraulic modeling? State the different types of model distortion.
i) Using the dimensional analysis, prove that Reynolds number for a flow in a pipe is a function of the density, the average velocity, the pipe diameter and the dynamic viscosity.

Question No. 2 (10%+10%)

j) A trapezoidal channel with side slopes 2H:1V is to carry 1? m^3/s at a bottom slope of 0.001 under uniform flow conditions. If the channel is to be lined with galvanized iron having n=0.011, calculate the minimum square meters of sheet required for lining of 100 m length.
k) A trapezoidal channel having side slope angle of 30^o carries a water discharge of $10 m^3/s$ with a depth of flow of 1.5 m and bottom width of 3 m under uniform flow conditions. If the bed slope is 0.0009, compute (i) the average shear stress in N/m2 on the boundary, (ii) Manning's n value, (iii) Chezy roughness coefficient, (iv) Darcy friction factor and (v) check the validity of the expressions $n=R^{1/6}/C=(f/8g)^{0.5}R^{1/6}$.

Question No. 3 (15%)

A trapezoidal channel carries a discharge of 390 cfs having a bed width of 18 ft, side slopes of 2H:1V, bottom slope of 0.0018 and Manning's n of 0.025. A weir is constructed to control and regulate the flow in the channel. The depth of flow just US the weir is 5.1 ft. Assuming the velocity is non-uniform and the kinetic energy correction factor is 1.15, determine the type of the water surface profile and compute the its length using direct step method (only 2 steps are required). End your calculation when the depth reaches 10% greater than the normal depth.

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Question No. 4. (15%+5%)

a) A rectangular channel carries a unit discharge of 100 cfs/ft and having a water depth of 10 ft. Plot the TEL and the HGL for the following cases:

(i) a smooth hump of 1 ft is constructed.

(ii) a smooth depression of 1 ft is constructed.

(iii) the maximum possible height of a smooth hump to produce a critical flow over the hump.

b) A Pelton wheel develops 1500 kw, while discharging 3 m^3/s of water at 300 rpm. Find the corresponding power, discharge and speed of 1/9 scale model, assuming efficiencies of the two turbines to be the same.

Question No. 5 (20%)

A vertical sluice gate installed in a long rectangular channel 5 m wide having an opening of 0.67 m produces a downstream jet with a depth of 0.4 m (at the vena contracta). The channel carries a discharge of $4m^3/s/m$. If the flow downstream from the gate is uniform flow with a depth of 2.5 m (tail depth):

(i) Check whether a hydraulic jump forms DS of the gate.

(ii) if a hydraulic jump forms, calculate the head loss through the jump.

(iii) if the head loss through the gate is assumed as 0.05 the velocity head at the vena contracta, calculate the depth US the gate and estimate both the hydrostatics and the dynamic forces on the gate.

(iv) if the downstream depth is increased from 2.5 m to 3m analyze the flow conditions at the gate.

Question N. 6 (20%)

(a) Differentiate between pumps connected in series and pumps connected in parallel.

(b) The pump having the characteristics given by the table is to be used in a pipeline system with the following characteristics: two tanks with 40 ft difference in static water surface, f=0.02, 8 in diameter, 1000 ft long, 4 bends each have K=0.9, one globe valve (US of the higher tank) with K=10, the pipeline is connected to the tanks at sharp edges.

Find (i) the operating conditions of the pump, (ii) decide the suitability of the pump, (iii) input power of the pump.

The pump characteristics are

Q gpm	0	500	800	1000	1300	1600
H ft	124	119	112	104	90	70
Eff. %	0	54	64	68	70	67

With our best wishes
Hydraulics staff members.

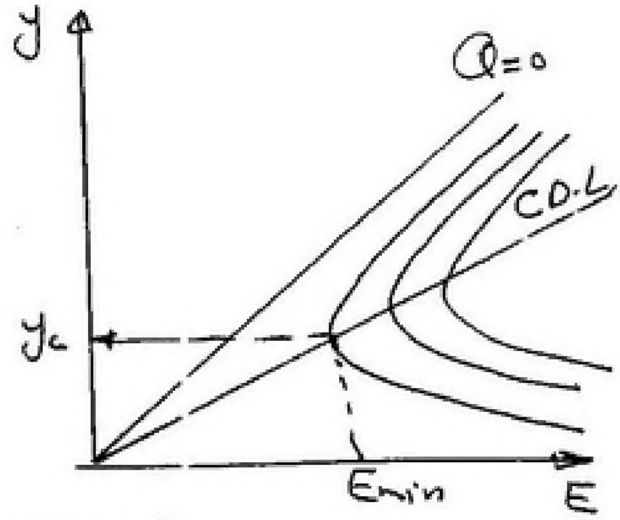
بسم الله الرحمن الرحيم

Final 2007

Q(1):

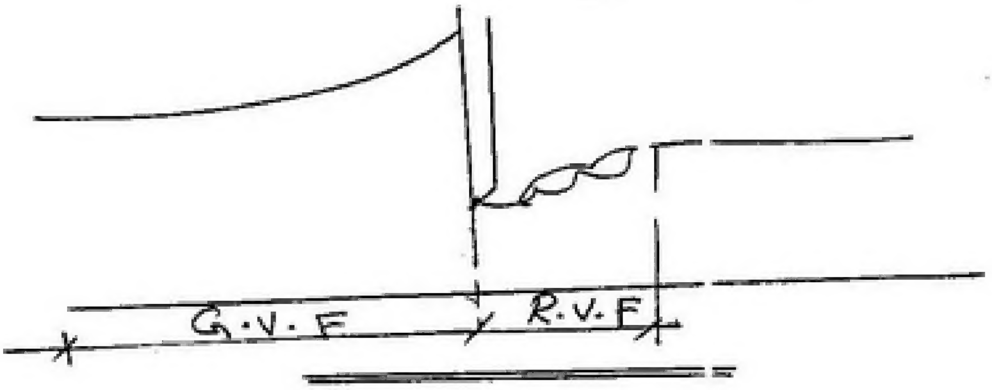
CDL: critical depth line

هو المحل الهندسي لجميع الاعماق التي قيمتها هي العمق الحرج (y_c)



R.V.F:

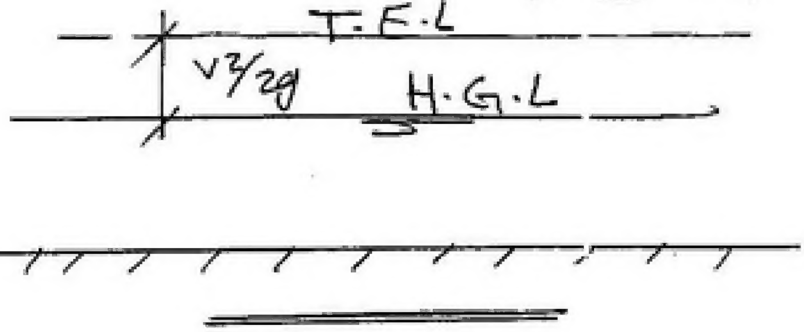
هو السريان الذي تتغير عمقه سريعاً على مسافة أفقية قصيرة نسبياً.



G.V.F: هو السريان الذي تتغير عمقه تدريجياً مع مسافة افقية كبيرة نسبياً

T.E.H: Total energy line

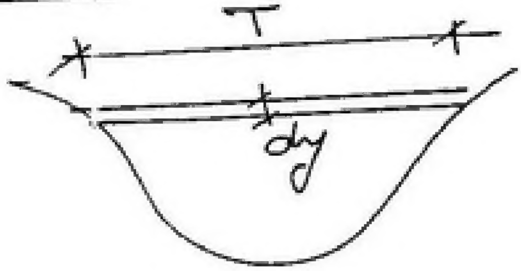
هو خط يوضح قيمة الطاقة الكلية عند اى قطاع على امتداد المسار



H.G.L:

هو خط يوضح ميل عمق سطح الماء على امتداد المسار

(b):



$$dA = T \times dy$$

$$\frac{dA}{dy} = T$$

$$\because \quad E = y + \frac{V^2}{2g}$$

for $Q = A \times V \Rightarrow V = \frac{Q}{A}$

$$E = y + \frac{Q^2}{2gA^2}$$

for $E_{min.}$ $\quad \frac{dE}{dy} = 0$

$$0 = 1 - \frac{\cancel{2} Q^2}{\cancel{2} g A^3} \times \frac{dA}{dy}$$

$$1 = \frac{Q^2 \cdot T}{g \cdot A^3}$$

$$\frac{Q^2}{g} = \frac{A^3}{T} \quad \#$$

(c): اثبات معادلة

G.V.F.

$$\frac{dy}{dx} = \frac{S_o - S_E}{1 + \frac{d}{dy}\frac{V^2}{2g}}$$

(d): اثبات B.H.S للقطاع Rectangular

$$\longrightarrow B = 2y$$

$$R = \frac{A}{P} = \frac{b \cdot y}{b + 2y} = \frac{2y^2}{4y}$$

$$R = \frac{y}{2} \quad \#$$

(f) :

$$Q_r = L_r^{2.5}$$

$$Q_r = \frac{L_r^3}{T_r}$$

For froude similarity $T_r = L_r^{1/2}$

$$Q_r = \frac{L_r^3}{L_r^{1/2}} = L_r^{2.5} \quad \#$$

(g) :

أهمية dimension analysis

١- تقليل عدد المتغيرات المدروسة .
٢- ايجاد العلاقة بين المتغيرات
٣- تسهيل الحل العملي .
٤- اعطاء حل مبدئي للمعادلة .

(h) :

أهمية Modelling

١- دراسة حالات التحميل المختلفة .
٢- تحديد عيوب المنشأ .
٣- تقليل تكاليف الانشاء

انواع الـ distortion

1- geometric distortion
2- Material "
3- Configuration "

(i):

$$(\overset{F.L.T}{\rho}, \overset{L.T}{V}, \overset{L}{D}, \mu)$$

- No. of variables = 4
- No. of Repeated = 3
- No. of π = 4 - 3 = 1

$$\pi = V^a \cdot D^b \cdot \mu^c \cdot \rho$$

$$(\overset{V}{L \cdot T^{-1}}, \overset{D}{L}, \overset{\mu}{F \cdot T \cdot L^{-2}}, \overset{\rho}{F \cdot L^{-4} \cdot T^2})$$

للتوضيح

$$\tau = \mu \cdot \frac{V}{y}$$

$$\mu = \frac{\tau \cdot y}{V} = \frac{F \cdot L^{-2} \cdot L}{L \cdot T^{-1}} = FTL^{-2}$$

$$\rho = M \cdot L^{-3}$$

$$F = M \cdot L \cdot T^{-2}$$

$$M = F \cdot L^{-1} \cdot T^{2}$$

$$\rho = F \cdot L^{-4} \cdot T^{2}$$

$$F^{0} L^{0} \cdot T^{0} = (L \cdot T^{-1})^{a} \cdot (L)^{b} \cdot (F \cdot T \cdot L^{-2})^{c} (F \cdot L^{-4} \cdot T^{2})$$

$$F : 0 = c + 1 \Rightarrow c = -1$$

$$T : 0 = -a + c + 2$$

$$a = -1 + 2 \Rightarrow a = 1$$

$$L : 0 = a + b - 2c - 4$$

$$0 = 1 + b + 2 - 4 \Rightarrow b = 1$$

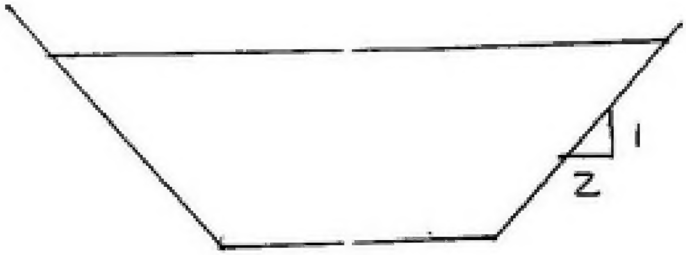
$$\Pi = \frac{V \cdot D \cdot \rho}{\mu} \qquad R = \frac{V \cdot D}{\nu}$$

$$\therefore \frac{\rho}{\mu} = \frac{1}{\nu}$$

$$\Pi = \frac{V \cdot D}{\nu} = R_n \quad \#$$

Q (2) :

(a)



$Q = 17 \ m^3/s$

$S = 0.001$

$n = 0.011$

Req.: area of steel Required for lining 100 m of canal

Sol.:

$$\because Q = \frac{1}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$$

$$A = (b + zy)y = (b + 2y)y$$

$$P = b + 2y\sqrt{1+z^2} = b + 2y\sqrt{1+2^2}$$

$$= b + 4.47y$$

$$17 = \frac{1}{0.011} \times \frac{[(b+2y)y]^{5/3}}{[b+4.47y]^{2/3}} \times (0.001)^{1/2}$$

$$5.91 = \frac{[(b+2y)y]^{5/3}}{[b+4.47y]^{2/3}} \longrightarrow (1)$$

for minimum Lining $R = \frac{y}{2}$

$$\frac{A}{P} = \frac{y}{2}$$

$$\frac{(b+2y)\cancel{y}}{b+4.47y} = \frac{1\cancel{y}}{2}$$

$$2b + 4y = b + 4.47y$$

$$b = 0.47y \longrightarrow (2)$$

from (2) in (1)

$$5.91 = \frac{[(0.47y+2y)y]^{5/3}}{[0.47y+4.47y]^{2/3}}$$

$$5.91 = \frac{[2.47y^2]^{5/3}}{[4.94y]^{2/3}}$$

$$5.91 = \frac{4.51\, y^{10/3}}{2.9\, y^{2/3}}$$

$$3.8 = y^{8/3} \Longrightarrow y = 1.65\,m$$

$$b = 0.80\,m$$

P for 1 m $= 0.8 + 4.47 \times 1.65$

$= 8.2$ m

P for 100 m $= 8.2 \times 100 = 820 \, m^2$

m^2 820 كمية الحديد المطلوبة للتبطين

(b):

$\because \tan 30 = \frac{1}{Z}$

$Z = \frac{1}{\tan 30}$

$Z = 1.73$

- $Q = 10 \; m^3/s$
- $y = 1.50$ m
- $b = 3.0$ m
- $S = 0.0009$

Req.: (i) τ (iii) C

(ii) n

(iv) f

(v) Check validity

$$n = \frac{R^{1/6}}{C}$$

$$n = (f/8 \cdot g)^{0.5} \times R^{1/6}$$

Sol.:

(i) $\tau_0 = \gamma \cdot y \cdot S$

$= 1000 \times 1.5 \times 0.0009$

$= 1.35 \ kg/m^2$ #

$= 1.35 \times 9.81 = 13.24 \ N/m^2$ #

(ii) $\because Q = \frac{1}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$

$A = (3 + 1.73 \times 1.5) \times 1.5 = 8.4 \ m^2$

$P = 3 + 2 \times 1.5 \sqrt{1 + 1.73^2} = 9.0 \ m$

$$10 = \frac{1}{n} \times \frac{(8.4)^{5/3}}{(9)^{2/3}} \times (0.0009)^{1/2}$$

$$n = 0.024 \ \#$$

(iii) $$Q = C \times \frac{A^{1.5}}{P^{1/2}} \cdot S^{1/2}$$

$$10 = Q = C \times \frac{(8.4)^{1.5}}{(9)^{1/2}} \times (0.0009)^{1/2}$$

$$C = 41.07 \ \#$$

(iv) $$f = \frac{8g}{C^2}$$

$$f = \frac{8 \times 9.81}{41.07^2}$$

$$f = 0.0465 \ \#$$

(v) $$n = \frac{R^{1/6}}{C}$$

$$R = \frac{A}{P} = \frac{8.4}{9} = 0.933$$

$$n = \frac{(0.933)^{1/6}}{41.07} = 0.024$$

المعادله سليمه للاستخدام

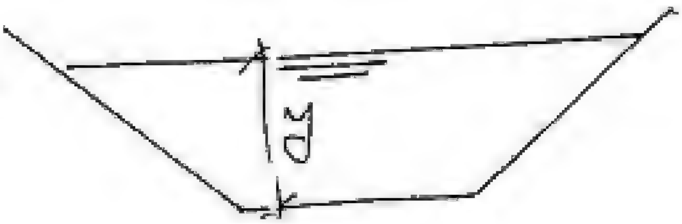
$$n = \left(\frac{f}{8 \cdot g}\right)^{0.5} \times R^{1/6}$$

$$= \left(\frac{0.0465}{8 \times 9.81}\right)^{0.5} \times (0.933)^{1/6}$$

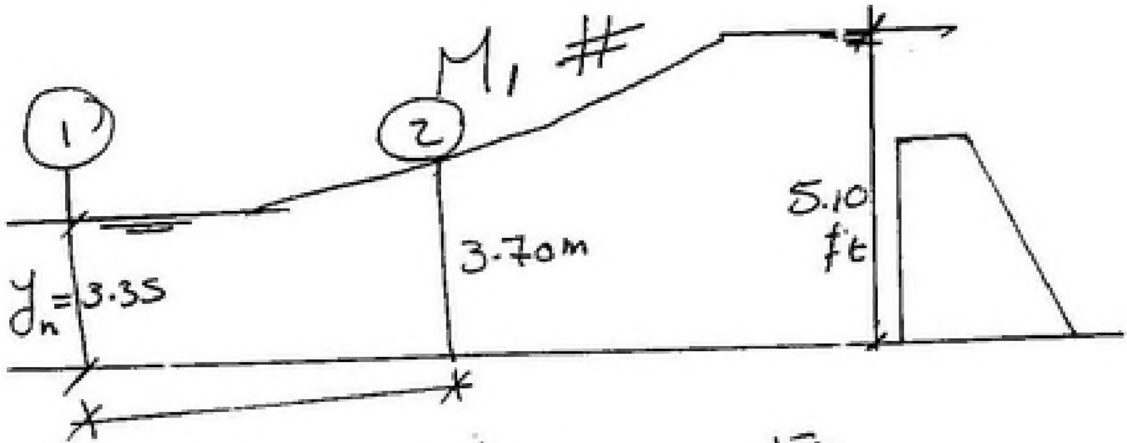
$$n = 0.024$$

المعادله سليمه.

Q(3):



- $Q = 390 \ ft^3/s$
- $b = 18 \ ft.$
- $Z = 2$
- $S = 0.0018$
- $n = 0.025$



U.S up stream

D.S down stream

$\rightarrow \alpha = 1.15$

<u>Req.:</u> – Type of water surface profile

– Length.

<u>Sol.:</u>

$$\because Q = \frac{1.486}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$$

$$A = (18 + 2 \times y)\,y$$

$$P = 18 + 2y\sqrt{1+2^2} = 18 + 4.47y$$

$$390 = \frac{1.486}{0.025} \times \frac{\left[(18+2y)y\right]^{5/3}}{\left[18+4.47y\right]^{2/3}} \times (0.0018)^{1/2}$$

$$\underline{154.65} = \frac{\left[(18+2y)y\right]^{5/3}}{\left[18+4.47y\right]^{2/3}} \quad \text{by trial}$$

y	3	3.5	3.25	
R.H.S	125.17	165.5	<u>144.6</u>	

$$\boxed{y \simeq 3.35}$$

$$\because \frac{Q^2}{g} = \frac{A^3}{T} \quad \text{at } y = y_c$$

$$A = (18 + 2y_c)\, y_c$$

$$T = b + 2zy = 18 + 2 \times 2 \times y_c = 18 + 4y_c$$

$$4723 = \frac{(390)^2}{32.2} = \frac{\left[(18+2y_c)y_c\right]^3}{\left[18+4y_c\right]} \quad \text{by trial}$$

y_c	3	2		
R.H.S	12441.6			

$y > y_c$

$S_o < S_c$ (Mild)

by direct step method

$$\Delta x = \frac{\Delta E}{\Delta S}$$

$$\Delta E = E_2 - E_1$$

$$\Delta S = S_o - S_{E\,av.}$$

$$S_E = \frac{n^2 \cdot V^2}{R^{4/3}}$$

$$E = y + \frac{\alpha V^2}{2g}$$

$A = (18 + 2y)\,y$, $E = y + \frac{\alpha v^2}{2g}$, $\alpha = 1.15$

$Q = 390$, $P = 18 + 4.47y$, $S_E = \frac{n^2 \cdot v^2}{R^{4/3}}$

Q/A A/P

sec.	y	A	V	E	ΔE	P	R	S_E	$S_{av.}$	ΔS	ΔX
1	3.35	82.75	4.71	3.75		32.97	2.51	4.6×10^{-3}			
					0.25				3.71×10^{-3}	1.91×10^{-3}	131 ft
2	3.7	93.98	4.15	4.0		34.53	2.72	2.82×10^{-3}			